

Blue Sky Amateur Radio Networking Starting from Scratch

The group of amateur radio operators in the Seattle, Washington area that I call the "Puget Sound Amateur Radio TCP/IP Group" (many prefer to call it the "WetNET Group") operates four 9600 baud bit-regenerative repeaters in the Seattle area (several more are in the works or undergoing conversion). The repeaters are on various bands: Three are on UHF, and one is on 222 MHz (which eventually may be converted to 9600 baud) and 2 meters. The predominant "mode" used on this network of repeaters is TCP/IP,

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User's computer ← (Ethernet1) → Linux PC ← (Ethernet2) → Radio

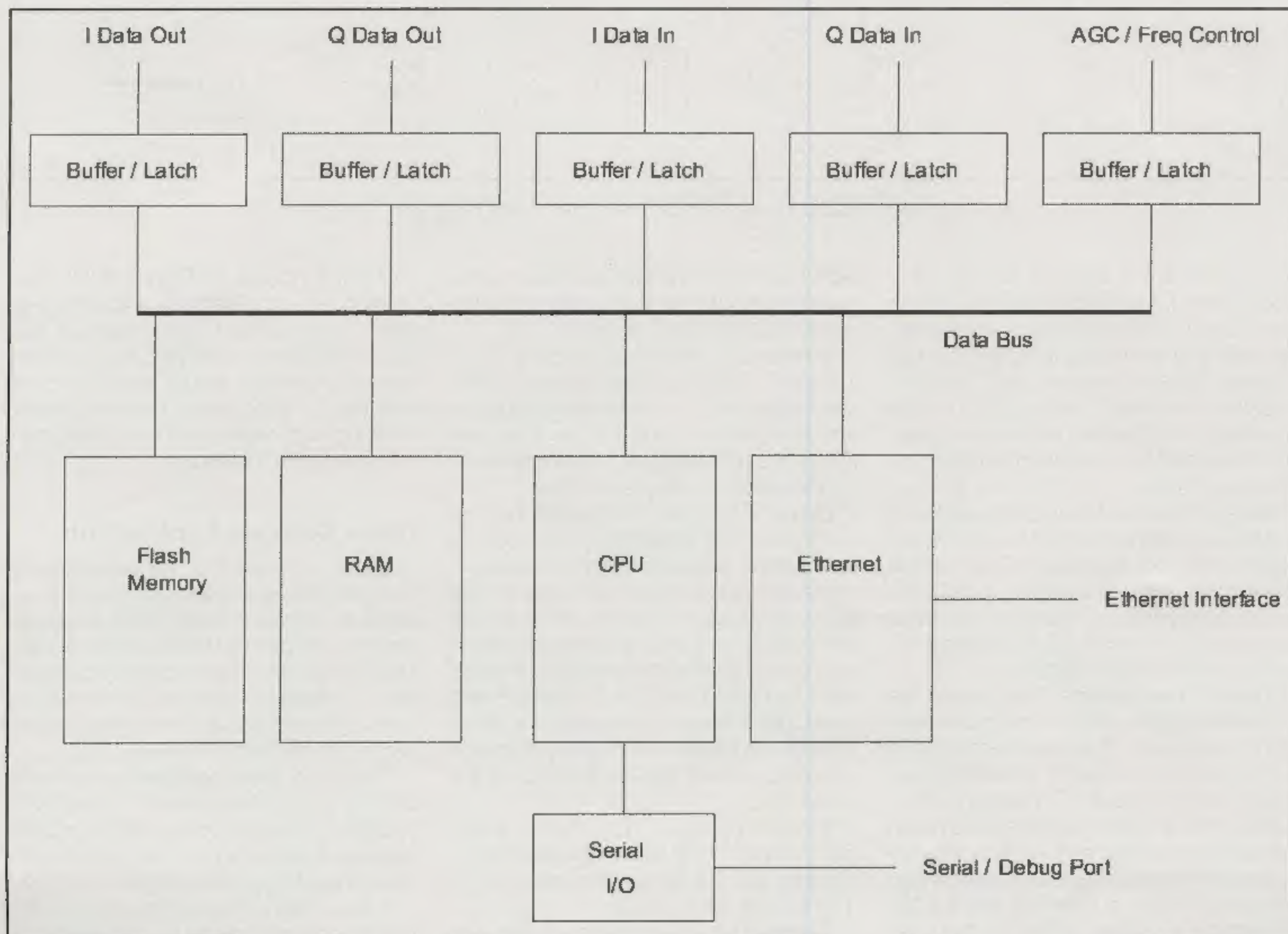
Fig. 1— Proposed basic structure of a data-oriented SDR that would use a PC to handle the DSP and networking/protocol chores.

and we've had an internet gateway online almost since the beginning of this network. I feel it's notable that we've been doing "Wireless Internet Access" for more than a decade now.

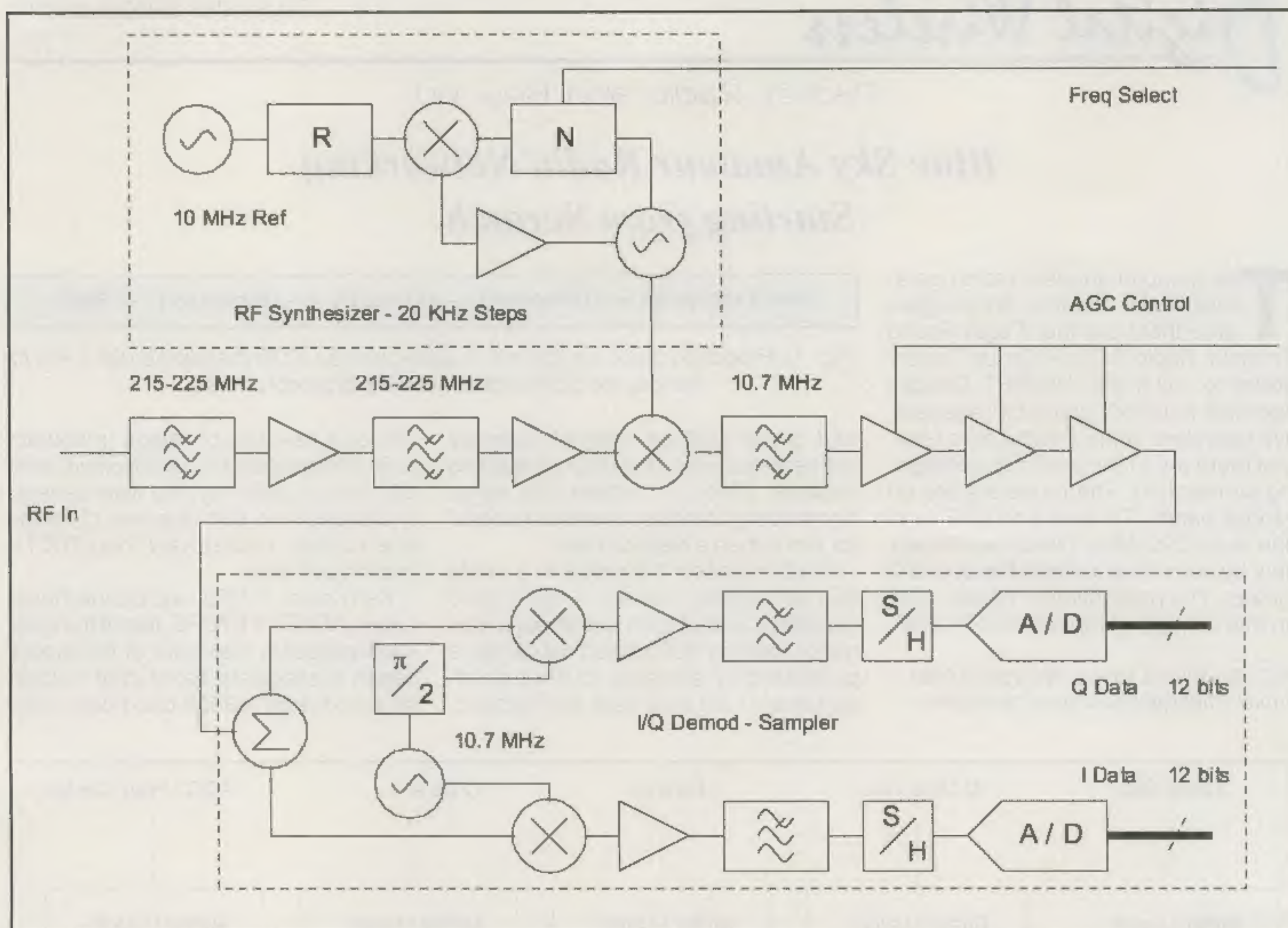
For this reason, the group as a whole has an ongoing interest in 9600 baud capability, and at least one of each new radio claiming 9600 baud capability is purchased by someone in the extended group. Last year saw the introduc-

tion of a new line of radios (manufacturer deliberately left unspecified) with 9600 baud capability. We were severely disappointed with this line of radios due to their excessively long RX/TX turnaround time.

Ken Koster, N7IPB, and Dennis Rosenauer, AC7FT/VE7BPE, two of the most knowledgeable members of the group, began to speculate about what it would take to design a 9600 baud data radio



Seattle Software Radio Project, radio-digital block diagram, version 0.1. (Diagrams courtesy Dennis Rosenauer, AC7FT)



Seattle Software Radio Project, radio-receiver block diagram, version 0.1.

that would work well. Of course, this opened the floodgates: 9600 baud is too slow to bother, cheap should be the goal, why not add additional features such as Forward Error Correction, etc. The discussion "devoled" (with good humor) from there, but then we reconvened after the ideas had been allowed to digest for a week or so.

What ended up being proposed was a data-oriented Software Defined Radio (SDR) that would use a PC to handle the Digital Signal Processing (DSP) and networking/protocol chores. The basic structure is shown in fig. 1, and working our way from left to right...

User's computer. This would be *whatever* is the preferred computer platform of the user. For most hams this is a PC running Windows®-something. For many others it is a PC running Linux. Others prefer UNIX workstations (such as Sun), or Amiga, or ????. The only requirement for the user's computer is that it have an Ethernet interface and a TCP/IP networking stack. Note that there will be no "special" applications running on the user's computer, and the Seattle

Software Radio System will "look" to the user's computer as just another device on its local 10baseT network.

Ethernet1. Typically, this will be 10baseT (10 Mbps, twisted pair), chosen because it is completely ubiquitous and inexpensive, and the troublesome issue of establishing a "radio interface" on the user's computer is done.

Linux PC. This PC would be the equivalent of a dedicated processor; as envisioned, it wouldn't be the user's primary computer used for day-to-day tasks. Instead, it would be dedicated to performing the Digital Signal Processing tasks *and* the networking (protocol code/decode) tasks. Once the DSP and networking tasks are completed for a packet, the packets are sent out on one of two Ethernet interface cards in the Linux PC.

Ethernet2. Again, typically this would be 10baseT (10 Mbps, twisted pair), chosen for the same reasons as the 10baseT for Ethernet1.

Radio. The radio section of the system portion would be minimal—a basic radio front end, and Digital to Analog

(D/A) and Analog to Digital (A/D) conversion resulting in clock and data signals. The A/D and D/A stages of the radio would be managed by a microcontroller, which would communicate with the Linux PC over Ethernet, likely sending and receiving User Datagram Protocol (UDP) packets.

Some Detailed Explanation

The primary inspiration for the approach outlined above is the phenomenal success of amateur radio DSP development being done with PC sound cards. However, it was felt that this approach was limited in how much could be accomplished due to the limited nature of the sound card hardware.

The "hard" work had been done—the DSP routines. Now what if those DSP routines could be combined with DSP hardware more suited for the task at hand than PC sound cards?

A secondary inspiration was that PC processors and memory, including laptops, were advancing at a phenomenal rate, and it seemed perfectly possible in

a 2002-era PC, even a modest one, to have sufficient bandwidth to perform considerable DSP work in the background as well as run other tasks.

Linux was chosen as the development Operating System (OS) of choice, because it has all the required (open source) networking, it very efficiently multi-tasks, development tools are all available free, and there is a well-established library of DSP sound-card routines available.

This approach satisfies many of the requirements/wishlist items:

- Because the RF hardware will be relatively modest, it should be inexpensive and relatively easy to develop.

- 222 MHz was chosen because it is the most "experimentation friendly" of amateur radio's available VHF/UHF bands; parts are readily available and layout is easier than at higher frequencies.

- Using a 20 kHz (standard VHF/UHF bandplan) channel, it may well be possible to achieve speeds consider-

ably faster than 9600 baud. To date, faster amateur radio data communications using simple two-state Frequency Shift Keying (FSK) have required channels wider than 20 kHz. It may well be possible to achieve 80 Kbps using 16QAM (Quadrature Amplitude Modulation), and after adding minimal Forward Error Correction (FEC), end up with 56 Kbps... again, in a 20 kHz channel. For comparison, the long-established WA4DSY 56K modem requires a 100 kHz channel.

- No need to reinvent or port networking code.

- Linux's advanced networking capabilities (including support for Internet Protocol version 6 [IPv6]) offers the possibility of advanced networking development.

- Use of a well-supported and common interface—Ethernet—ensures that the computing platform is not restricted to PCs.

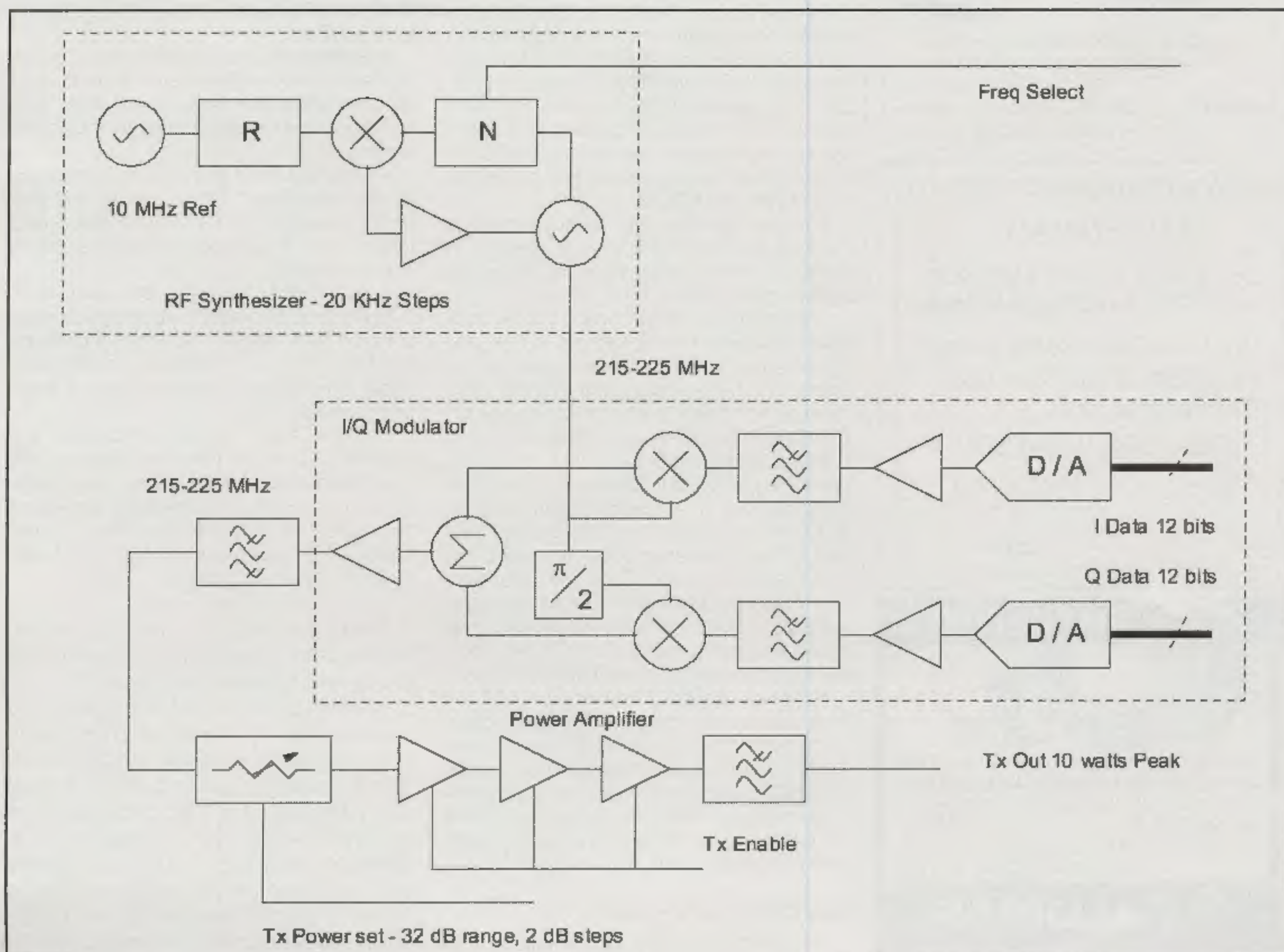
- Multiple radios can be supported (physically) with the addition of an

Ethernet hub and can even be separated physically from the computer and each other.

The Ongoing Project

From the beginning, the entire project was envisioned as operating as Open Source, with software distributed under the GNU Public License and the hardware intellectual property (schematics, board layouts, etc.) also being made available as Open Source, possibly using the OpenIPCore Hardware General Public License. Documentation of the project is the automatic archiving on the project's mailing list (see below). Because of the mix of "platform preferences," diagrams, etc., will be built with UNIX open-source tools, such as xfig.

There is need for some specific skills, especially as the project evolves past the design stage, but for the moment, the ongoing project is envisioned as largely local to the Seattle area. If you wish to monitor the progress of the pro-



Seattle Software Radio Project, radio-transmitter block diagram, version 0.1.

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ject, it is being documented on the group's (actively being revised) web page at <<http://www.seatcp.net/>>; follow the Projects link. You can also monitor the progress of the project via the Soft Radio mailing list. To subscribe to the list via on the web, go to <http://wetnet.seatcp.net/mail_lists/>, or send an e-mail to <<mailto:majordomo@seatcp.net>> and put "subscribe softtrad" in the body of the message.

Other Potential Networking Approaches

As is also the habit of the "WETNet Group," nothing is ever cast in stone, and projects/approaches to new networking systems continue. Here are a few highlights from some recent discussions (slightly edited for publication):

From Dennis Rosenauer, AC7FT:

A while back I did a design using a Motorola 68en302, which is the same processor that is used in the TNC3 but with an Ethernet. The PCB layout is 80% done. I have yet to route the power busses.

Basically what I have is a 68en302 on a double-sided board. It is fairly large due to only being two sides (about 7" x 9" if I remember right). It has two RS-422 ports, one RS-232 port, and a 10 Mbit/sec. Ethernet with both AUI and 10-baseT connectors on it. It has old PC memory sockets on it for 2 x 1 MByte DRAM and two sockets for a total of 512K bytes of EPROM.

The cost of the '302 is about \$45 at DigiKey, the Ethernet chip is \$18, and I don't know the cost of anything else. I have no software for it.

I was working in this direction a while back when I expected more interest in 56K and higher speeds, but the project got pushed farther and farther back on the stove. (*The "distraction" that Dennis hints at was his marriage to his lovely wife Chris.—ed.*)

It would have the capability of running something like NOS if you were to do a major cross compile for it. I was targeting running RTEMS (a real-time operating system) on it and writing application code to make it into an Ethernet-to-radio bridge with two radio interfaces on it. I only got as far as setting up the GCC cross compiler for the 68K core processor and getting some of the run-time libraries together ready to port RTEMS to the 68K.

Now here is where I put my foot in it!!! If there are enough people interested, I could be convinced to finish the PCB layout. I could even be convinced to change the memory to something a little newer. I would be willing to make a run of PCBs, but someone else would have to handle getting parts and doing some documentation. Any interest?

Ken Koster, N7IPB, wrote:

OK, gang, time to put up or whatever. The offer has been made, and it's up to you to make it happen. We've done this in the past

and nothing happens... How about this time?

While completing projects like this can be done by one or two individuals, we have to be highly motivated and have a big personal interest in the project. The motivation can quickly go away if it seems no one else cares enough to help out.

Dennis already has other projects to work on, a life, a job, a 56K repeater, welding gear to play with, a software radio. ... He doesn't really need another project, so unless help shows up, it won't happen.

The group as a whole needs to figure out what they want to do. What radios, modems, TNCs, etc. Start up a discussion right here on the mailing list, get involved, put forth proposals. I'll even start the ball rolling, but I expect others to chime in and continue the discussion. So here goes:

- Do nothing—Slide along with 1200 and 9600 with minor incremental changes.

- 56K—Dennis's repeater on 440 to start with, simplex LANs for others. Needs a radio; could be the Dutch ones. Also needs a modem; could be the PacComm or might get an old GRAPES modem.

- Dennis's 56K design uses parts that are now obsolete and would require a redesign (and help from the audience). Also needs a high-speed interface; could be the TNC3, Dennis's 302 board, or the PCISCC board from BayCom.

- Software Radio—It will do 9600, possibly faster, not for quite some time. It won't be compatible with 56K unless done as a redesign. Don't expect anything for a year or more.

- Modified 802.11b systems [long a topic of discussion] with higher power and pre-amps, operating on 2.4 GHz amateur radio frequencies. The biggest problem is adding power control.

- Adapt 802.11b systems to operate on 1.2 GHz amateur radio frequencies to avoid colliding head-on with the Part 15 users on 2.4 GHz. This will require the design of a transverter system in reverse, and a feasibility study.

That's a start. Time for discussion and comment. Cast your votes and come up with a consensus. You will be graded on the quality of your comments, the thoroughness of your analysis, and the originality of new ideas. I'll be disappointed if we have less than two dozen responses.

There was much more discussion, but the comments from Dennis and Ken pretty well framed the issues.

I think that the Seattle Software Radio System (SSRS) is a very valid approach, and if it is able to achieve any traction at all with amateur radio as a whole, it could really revolutionize the hobby. Such an approach would take a "middle ground" between what is possible with "purely software" approaches such as what is currently being done with sound cards, and the development of standalone systems that do all the processing on embedded processors and memory. The

former approach is highly cost effective but limited in what can be accomplished overall. The latter approach isn't cost effective (the resultant product is expensive) but is unlimited in what can be accomplished overall.

Although the initial SSRS is targeted at "9600 and faster" speeds, and 222 MHz frequencies, it seems to me that the modular approach would quickly allow those skilled in RF, but not necessarily in DSP or networking, to perhaps build a 1.2 GHz RF front end based on the "reference design" 222 MHz radio. This design approach—building on what others have done using previous work as reference—is referred to as "Open Source" in the Linux community.

The project that I would most like to see happen is to adapt existing Part 15 Frequency Hopping Spread Spectrum (FHSS) radios that operate in the 902–928 MHz band to operate in the U.S. amateur radio band of 420–450 MHz. I've written before that I feel that FHSS would be an ideal "overlay" to existing operations in the U.S. amateur radio 440 MHz band mostly because the repeaters that occupy the vast majority of the band consume only a fraction of the available channel time. Because the amount of spectrum available is similar,

only minor adaptations should be necessary, such as perhaps restricting an FHSS "not to hop" into segments reserved for space operations (*Please be sure to include EME and terrestrial weak-signal frequencies as well.*—ed.).

Correction and Update

Regarding my April 2002 column in which I discussed the Linksys WAP11 802.11b Wireless Access Point, Steve Lampereur, KB9MWR, responded with postings to several TAPR mailing lists (lightly edited for publication):

In the April 2002 issue of *CQ*, Steve Stroh,

N8GNJ, wrote in his "Digital Wireless" column: "Modifying a Part 15 Device, even attaching external antennas, is a violation of FCC Part 15 rules. A Part 15 certification is for the system, not just the "radio." Modifications void the "implied license for this device to transmit."

N8GNJ implies the "only" way around this is to re-classify under Part 97, as we are allowed to make such modifications...

"Equipment that has been certified for use in another service may be used on amateur frequencies by a licensed amateur as long as it meets all appropriate standards. (97.315)"

I wish this was the case, Steve. In your thorough reading of FCC rules, you failed to read all the pertaining sections. When deal-

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Seattle Software Radio Specs version 0.1 per AC7FT

Receiver

Freq. Range: 215–225 MHz
Continuous Tuning Range: 3 MHz
Step Size: 20 kHz
IF Bandwidth: 20 kHz nominal
Noise Figure: 10 dB
Sensitivity: 120 dBm for 1.0 V pp out on A/D
Sample Rate: 20 kHz I and Q (probably
closer to 24)
Resolution: 12 bits I and Q
AGC Range: 80 dB

Transmitter

Freq. Range: 215–225 MHz
Continuous Tuning Range: 3 MHz
Step Size: 20 kHz
Modulation Bandwidth: 20 kHz min.
Output Power: 10 watts peak
IMD: 25 dBc two tone at 5 watts
TX Gain Control Range: 32 dB in 2 dB steps
Sample Rate: 20 kHz I and Q
Resolution: 12 bits I and Q

Processor

Flash: 8 Kbytes min.
RAM: 32 Kbytes min.
Clock Speed: TBD
Ethernet I/F: 10baseT 10 Mbits/sec.

ing with any Part 15 device, not only do you
need to read 15.247, but also parts 15.205,
15.209, and 15.247. So I hope this was just
an oversight on your part.

Here is the Part 15 loophole: "Section
15.23. Equipment authorization is not re-
quired for devices that are not marketed, are
not constructed from a kit, and are built in
quantities of five or less for personal use."

More information on this is available at
<[http://www.qsl.net/kb9mwr/projects/
wireless/plan.html](http://www.qsl.net/kb9mwr/projects/wireless/plan.html)>.

And in a later message:

N8GNJ wrote, "... if you are able to mod-
ify the device in such a way that transmis-
sions are restricted to the amateur radio seg-
ment of the 2.4 GHz band..." "Since Linksys
has not, and likely will not, release detailed
enough information to be able to make such
a change, 'pure' amateur radio use of this
device doesn't seem likely..."

...The Linksys WAP11 is a DSSS 802.11b
device. All 802.11b devices have 11 user-
settable channels; the first 6 channels have
complete amateur overlap.

More information on this is available at
<[http://www.qsl.net/kb9mwr/projects/
wireless/dssfreq.html](http://www.qsl.net/kb9mwr/projects/wireless/dssfreq.html)>.

Maybe your Windows® driver doesn't let
you "lock" onto one particular channel. Try a
different 802.11b driver (they should be
interchangeable). Under Linux you can set
the channel using "iwconfig" or equivalent.

Bill Vodall, WA7NWP, wrote (lightly
edited for publication):

You can, of course, choose the channel
which your 802.11b Access Point will use.

There are three unique non-overlapping
802.11b channels; 1, 6, and 11. One and 6

are completely inside the ham segment and
11 is outside. I will be using my Part 15 home
wireless network at 11 as a token gesture to
not add to the noise floor for AO-40 and other
amateur activities.

Steve, KB9MWR, brings up an inter-
esting possibility. I've heard of the "un-
der five systems for personal use" pro-
vision he references, but I'm not familiar
with it, and refer interested readers to
Steve and the references he provides.

Ed Hare, W1RFI, of the ARRL added:
"This does assume, of course, that said
homebrew design [the 'under 5 provi-
sion'] is designed such that the design-
er reasonably believes that the device
complies with the rules."

As to "setting" 802.11b channels, I
completely blew it in this part of my
explanation. Steve and Bill are correct
in that the channel of an 802.11b device
is settable, but doing so is somewhat
problematic with the Windows® driver
included with the WAP11. As Steve and
Bill point out quite correctly, it is (rela-
tively) easy to operate an 802.11b de-
vice entirely with the amateur radio por-
tion of the 2.4 GHz band.

Digital Conference and "Coming Soon"

Mark your calendars and make plans to
attend the 21st Annual ARRL and TAPR
Digital Communications Conference, to
be held September 13–15, 2002 in Den-
ver, Colorado. The most up-to-the-
minute information on the DCC and the
various activities will be posted at
<<http://www.tapr.org/dcc>>.

In upcoming columns, I again hope to
discuss, as promised:

- My idea for a Wireless ISP Smart
Radio and how it relates to amateur
radio

- A "repeater grade" 802.11b Access
Point that could form the basis of an
802.11b network with long range.

- A line of high-speed radios and TNC-
like devices from Germany (<[http://
www.symek.com/g/index-g.html](http://www.symek.com/g/index-g.html)> if you
want to peek), and my impressions of
their product line in the face of what has
happened to 56K packet radio in the U.S.

- A visit to the headquarters of Shine
Micro (<http://www.shinemicro.com>) and
a discussion with Mark Johnson,
AC7PU, about its new SM2496-TNC, a
"TNC" implemented in software and a
DSP chip in a Springboard Slot form fac-
tor for the Handspring Visor line of Per-
sonal Digital Assistants. I think there's
a lot more to this development than is
readily apparent.

73, and please write!

de Steve, N8GNJ